LB-853

INTERLACED SAMPLING-SIGNAL GENERATOR

RADIO CORPORATION OF AMERICA

RCA LABORATORIES DIVISION

INDUSTRY SERVICE LABORATORY

RADIO CORPORATION OF AMERICA

RCA LABORATORIES DIVISION

INDUSTRY SERVICE LABORATORY

LB-853

Interlaced Sampling-Signal Generator

Approved

Stuart Wm. Seeley.

Interlaced Sampling-Signal Generator

Introduction

The operation of dot- or frequency-interlaced color television systems requires a source of sinusoidal color-sampling or color sub-carrier signal having a frequency which is an odd multiple of one-half line frequency. In order that the proper relationship between the sampling frequency and one-half line frequency be maintained, a signal at 31.5 kc which is suitable for driving a standard monochrome synchronizing signal generator (such as the RCA TG-1A) must be derived, by appropriate frequency division operations, from the sampling-frequency oscillator signal. Part I of this bulletin describes a unit for this purpose employing regenerative frequency dividers, which was developed for experimental work in color television. It derives a 31.5-kc driving signal from a crystal-controlled 3.89 Mc (nominal) signal. The 31.5-kc signal is the double-line frequency and 3.89 Mc the color-sampling frequency tentatively standardized by the National Television System Committee.

Part II of this bulletin describes a companion unit for the Interlaced Sampling-Signal Generator which provides distribution amplifiers for the sampling-signal and a source of marker pulses of 0.01 H repetition period.

Part I

General Discussion

Either the regenerative divider or the trigger-circuit-type counter can be employed to perform frequency division. Considerations which recommend the use of the former include its relative insensitivity to supply-voltage variations and its relative economy of tubes. At the frequencies encountered in this application the elements of the required tuned circuits of a regenerative-type divider are of convenient size and adequate stability.

A single divider stage consists of a mixer section and a multiplier section as shown in Fig. 1. For division from 5 Mc to 1 Mc, for example, the mixer plate circuit is tuned to 1 Mc and the multiplier plate circuit is tuned to 4 Mc. In the steady state, the mixer combines the input signal at 5 Mc and the signal from the multiplier plate at 4 Mc and selects the difference frequency of 1 Mc in its tuned circuit. This provides the input to the multiplier section, which multiplies by four and which completes the regenerative loop. In the transient state in which the signal levels are building up, the input signal must excite the mixer tuned circuit, and there must be sufficient loop gain that regeneration will occur and the desirable steady state condition will be achieved. It is also desirable, though not absolutely essential, to limit loop gain so that in the absence of an input signal the circuits are quiescent, preventing a spurious signal output.

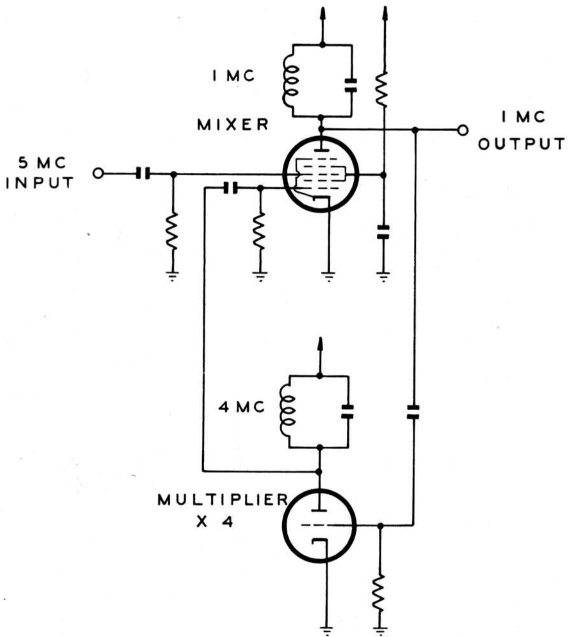


Fig. I - Typical single stage of regenerative division.

Description of Circuits

The unit, the schematic of which is shown in Fig. 2, may be considered in five sections: oscillator and buffer section, three sections of division, and 31.5-kc output. The buffer provides the color sampling-frequency output. The divisions are by five-fourths, nine and eleven.

Section (1) consists of a conventional crystal oscillator, V101, and a buffer-amplifier, V102. The buffer provides an output of approximately 20 volts p-p amplitude at a nominal impedance level of 75 ohms.

Section (2), the first stage of division, is a conventional regenerative divider made up of a mixer V103, and a multiplier, V104A. The mixer is driven by the buffer-amplifier of section (1). This stage performs a division of five-to-four; the desired divided output is present at the plate of the multiplier, V104A.

Section (3), which isdriven by the section (2) multiplier, performs a nine-to-one frequency division. This stage is a conventional regenerative divider, V105 being a mixer, and V104-B being a multiplier. The desired output is developed at the plate of the divider, V105.

Section (4), which is driven by the section (3) divider, again is a conventional regenerative divider circuit, V107 being a mixer, and V106A being a multiplier. This stage performs an eleven-to-one frequency division. The divided output is present at the plate of V107.

Section (5) is a resistance-coupled amplifier, V106B, providing the 31.5-kc output. This stage is driven by V107 through the RC filter formed by the 82K resistor and 51-μμf capacitor at the grid of V106B. This filter serves to attenuate the eleventh harmonic component present in the V107 plate current; the output of V106B approximates a 31.5-kc sine wave.

The 31.5-kc output is adjustable from 0-100 volts by means of potentiometer P1, and is intended to drive into a high impedance. The 31.5 kc signal at the top of P1 is also brought out to J12 to provide drive for the companion unit described in Part II of this bulletin.

The unit is assembled on a standard 5¼ inch dishpan-type chassis. Figs. 3 and 4 show front and rear views, respectively. Seven miniature tubes, and a crystal oven operating

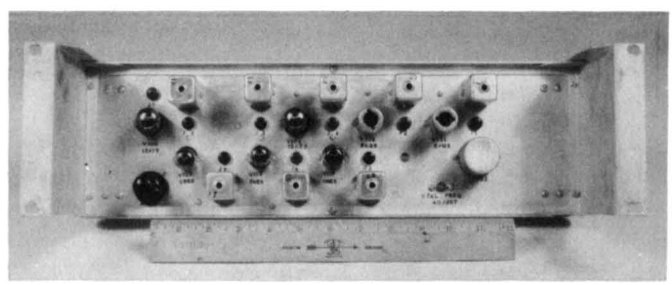


Fig. 3 - Front view of Interlaced Sampling-Signa Generator.

from the heater supply are employed. Power supply requirements are 100 ma at 300 volts and 3.1 amps at 6.3 volts. An RCA VC-1-C crystal ground for 3,898.125 kc at 75 degrees C, is mounted in a James Knights Co. JK02 crystal oven, operating at 75 degrees C, with a maximum

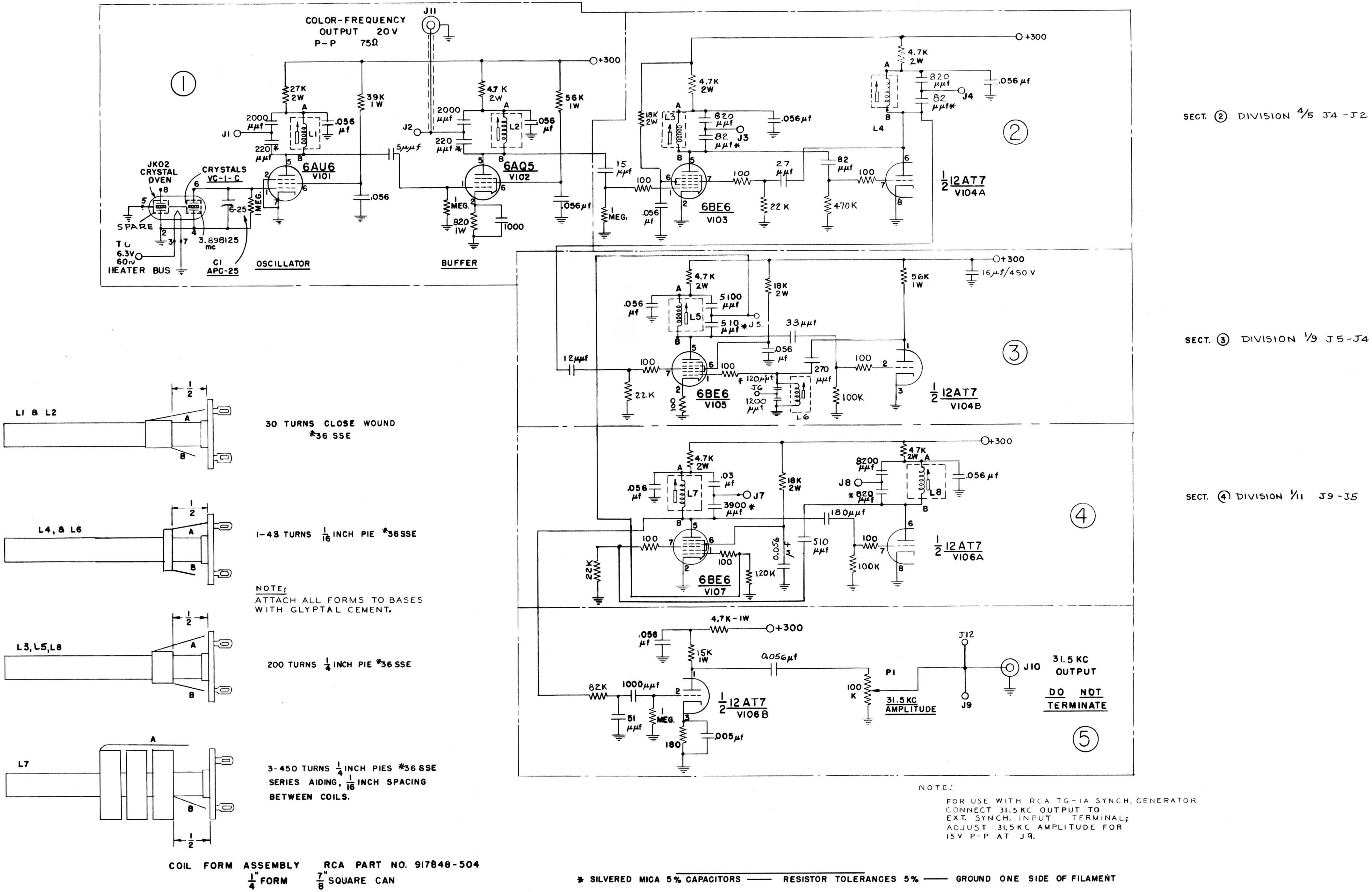


Fig. 2 - Schematic Diagram of Interlaced Sampling-Signal Generator.

temperature cycling range of ±2 degrees C. The maximum range of frequency variation for this configuration is ±12 cps; a typical range of frequency variation is ±6 cps. The range of frequency adjustment afforded by the crystal trimmer-capacitor is approximately 800 cps, permitting adequate compensation for aging or crystal replacement. The outputs of the unit are 3.89 Mc at 20 volts p-p amplitude at a nominal impedance level of 75 ohms, and 31.5 kc adjustable to 0-100 volts p-p amplitude at a high impedance level.

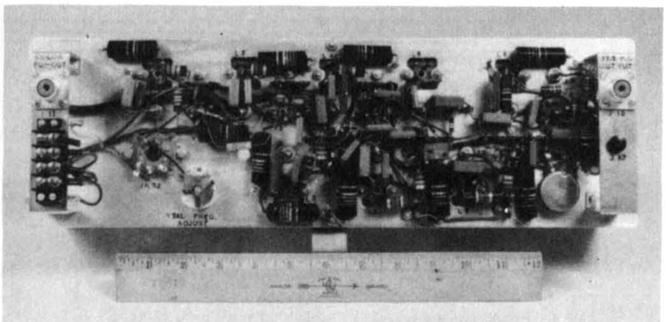


Fig. 4 - Rear view of Interlaced Sampling-Signa Generator.

Adjustment

General

Apply filament power, connect a 75-ohm termination to J11, and allow ten minutes warm-up to assure crystal stability, before proceeding with further adjustment. Apply plate power from a 300-volt regulated supply.

Oscillator Adjustment

For this and the remaining adjustments, an oscilloscope which focuses sharply, which has at least one wide-band channel, and which affords some gain at 400 kc in the other channel is required.

Connect J1 to the vertical amplifier input, and use any sweep. Advance the slug of L1 until oscillation is initiated. Note the signal amplitude. Continue to advance the slug of L1, noting the maximum signal amplitude. This immediately precedes an abrupt cessation of oscillation. Back off the slug of L1 until the amplitude is approximately 70 per cent of the maximum amplitude previously noted. The grid-to-plate capacitance of the oscillator should be adjusted by means of lead dress to provide an oscillator rectified grid bias of approximately 15 volts at 70 per cent maximum output. This assures stability of oscillation.

Buffer Adjustment

Connect J2 to the vertical amplifier input and use any convenient sweep. Adjust the slug of L2 for maximum output. Tuning of the buffer should have a negligible effect upon the amplitude of the oscillator output as measured at J1. This will be true if leads and components are placed in such a fashion that the oscillator grid is shielded from the buffer plate circuit.

First Divider Alignment

Connect J2 to produce horizontal deflection of the oscilloscope. Either the horizontal amplifier or direct connection to the deflection plates may be employed; use the connection which produces the largest deflection. A deflection of less than a centimeter is adequate if the spot is sharply focused.

Connect J4 to the vertical amplifier input. Screw the slugs in L3 and L4 well out of the coils. Advance the slugs by equal increments into both coils, observing the oscilloscope pattern. A point will be reached at which a Lissajous pattern will be formed. The correct Lissajous pattern is shown in Fig. 5a. Slight readjustment of the slugs should produce a steady, readable, pattern. Read the vertical to horizontal frequency ratio. If this ratio is greater than the desired ratio advance the slug of L3, and back off the slug of L2 until the desired pattern is obtained. If the ratio obtained is smaller than the desired ratio, back off the slug of L3 and advance the slug of L2 until the desired pattern is obtained.

A range of combinations of slug positions exists for which the desired division takes place. This range should be explored by a "rocking-in" technique: one slug is moved in small increments while the other slug is moved repeatedly over the range for which the desired division takes place. The slugs should be set in that combination of positions which produces the most stable conditions.

Second Divider Alignment

Leave J4 connected to the vertical amplifier input. Connect J5 to the horizontal amplifier input. Advance the slug of L5 to the middle of its range. Gradually advance the slug of L6 until a Lissajous pattern is formed on the oscilloscope. The correct Lissajous pattern is shown in Fig. 5b. It may be necessary to readjust the slug of L5 in order to achieve a stable pattern. Read the vertical to horizontal frequency ratio. If this ratio is greater than the desired ratio, back off the slug of L5 and gradually advance the slug of L6 until the desired pattern is obtained. If the ratio obtained is smaller than the desired ratio, advance the slug of L5 and gradually back off the slug of L6 until the desired pattern is obtained. The slugs should then be adjusted for the most stable condition.

Third Divider Alignment

Connect J9 to the vertical amplifier input. Leave J5 connected to the horizontal amplifier input. Proceed as with the *second divider*, but read the horizontal to vertical frequency ratio. L7 corresponds to L5; L8 corresponds to L6. The desired Lissajous pattern is shown in Fig. 5c.

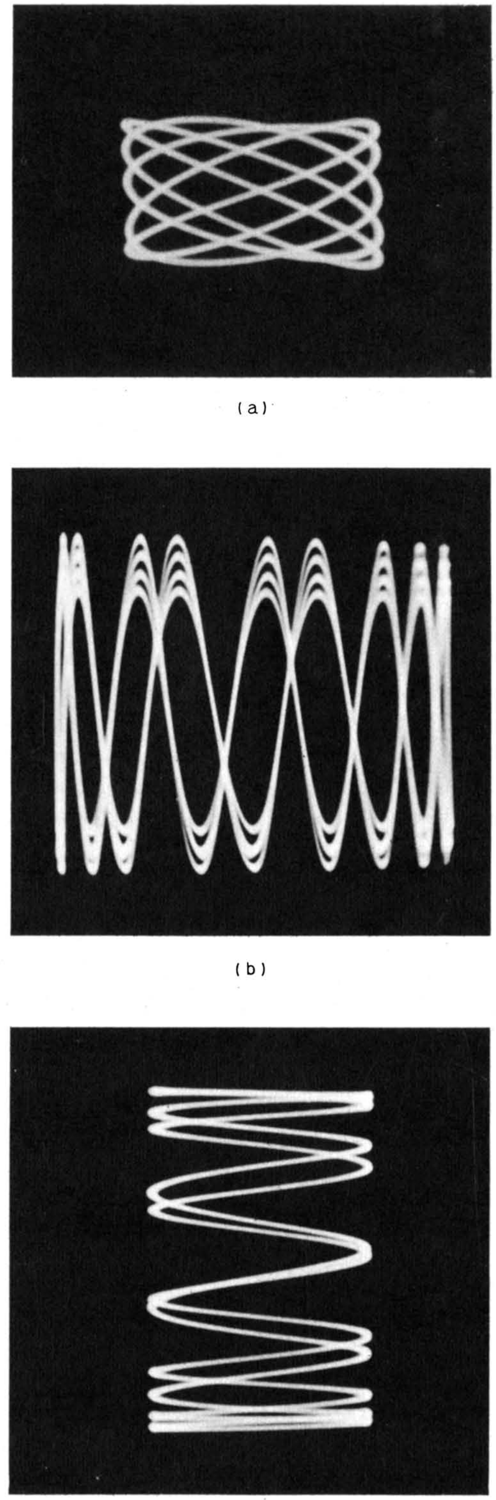
31.5-kc Output Adjustment

The amplitude of the 31.5-kc signal provided by the 31.5-kc output stage is adjustable to a maximum of 100 volts p-p by potentiometer [illegible], and may be measured at J9. The output impedance level is high; it should be recognized that the capacitance of the connecting cable will contribute to the load impedance.

In general, synchronizing-signal generators derive their output signals from an internal source of voltage at 31.5 kc of high amplitude and high impedance level. The 31.5-kc signal provided by the Interlaced Sampling-Signal Generator should be supplied to the synchronizing-signal-generator in such a fashion as to duplicate as nearly as possible the signal amplitude and source impedance of this internal source.

The RCA TG1A Synchronizing Generator may be driven by the Interlaced Sampling-Signal Generator by connecting the 31.5-kc output of the latter to the "Ext. Sync." terminal on the bottom chassis of the synchronizing generator, and placing the "Frequency Control" switch in the "Ext." position. The 31.5-kc amplitude should be set at 15 volts p-p at J9 of the Interlaced Sampling-Signal Generator.

When the Interlaced Sampling-Signal Generator 31.5-kc signal has been supplied to the sync-generator, observe the composite sync-and-blanking waveform on the oscilloscope, using a



(a)

(b)

(c)

Fig. 5 - Lissajous figures employed in alignment of Interlaced Sampling-Signal Generator.

60-cycle sine-wave sweep. When the sync-generator is properly controlled, the waveform will rotate slowly at the difference frequency between the power-line frequency and the field frequency. An erratic pattern, or a pattern which rotates at more than a few tenths of a cycle per second, indicates that the sync-generator is not properly controlled.

Oscillator Frequency Adjustment

When a precise adjustment of oscillator frequency is desired, the following method may be employed. The auxiliary equipment required consists of a communications receiver, a calibrated 2.5-Mc crystal source (such as the RCA WR-39-B Television Calibrator), an audio oscillator, and an oscilloscope. The 2.5-Mc crystal may be calibrated with respect to the Standard Frequency Transmissions of station WWV, Washington, D. C. These transmissions are at 2.5, 5, 10, 15, 20, 25, 30, and 35 Mc. By adjustment of the 2.5-Mc crystal frequency, a zero beat may be obtained between one of these transmissions and a harmonic of the crystal frequency. The audio oscillator may be calibrated with respect to the 31.5-kc output of the Interlaced Sampling-Signal Generator; a calibration at 10,500 cps is close to the frequency required in adjustment of oscillator frequency, and may be obtained by forming a three-to-one Lissajous figure on the oscilloscope. (This 31.5-kc reference is inaccurate only to an extent proportional to the inaccuracy of oscillator frequency. At the extremes of the range of the crystal trimmer-capacitor, the oscillator frequency is in error less than 0.03 per cent.)

For measurement of the 3.89 Mc frequency (3,898,125 cps design frequency) connect the Color Frequency Output (J11) to the input connector (J18) of the sampling signal distribution amplifier (or equivalent amplifier) which is a part of the Companion Unit described in Part II of this bulletin. There should be a 75-ohm termination at J15. Adjust the slug of L12 for maximum output at J19.

Connect J19 (terminated in 75 ohms) to the 2.5-Mc crystal calibrator input with a short wire, and connect a 1N34 germanium crystal diode from the input terminal to ground. The crystal may be connected with either polarity grounded.

A signal at the difference frequency between the 59th harmonic of the 3.89-Mc frequency (229,989,375 cps) and the 92nd harmonic of the 2.5-Mc crystal (230,000,000 cps) wil appear at the output of the crystal calibrator detector. This difference frequency is dependent on the particular frequency of the 3.89 Mc crystal oscillator, and may be varied from a frequency well above the audible range, through zero beat, and to another frequency above audibility on the other side of zero beat, by varying oscillator trimmer capacitor C1.

In order to obtain optimum amplitude of the difference frequency some slight readjustment of the plate tuning of V102 and V301 wil be required. The following procedure has been used.

Set the trimmer capacitor C1 so that the difference frequency is readily audible. A frequency of 3,000 to 5,000 cps has been found satisfactory. As mentioned previously, beat notes may be obtained on both sides of zero beat; these correspond to two positions of trimmer capacitor C1. The higher capacitance position is the proper one. Next, adjust the slug of L2 for maximum amplitude of the difference frequency. This adjustment may "pull" the oscillator frequency slightly; once this adjustment has been made, do not change th position of the slug in L2.

After the slug in L2 has been adjusted for maximum amplitude of the difference frequency, the plate tuning of V301 should also be adjusted for maximum amplitude of the difference frequency. This tuning adjustment should not pull the frequency of the oscillator.

The difference frequency may now be compared to a signal from the audio oscillator by means of the oscilloscope, and should be coupled to the oscilloscope through a 200-μμf capacitor to minimize the effect of hum present in the output of the television calibrator. Because of oven-temperature cycling, the detected difference frequency will vary over a range of about one thousand cycles at approximately one minute intervals. If the audio oscillator is set at a frequency within this range, it will be possible to observe th zero-beat condition when the detected difference frequency swings past the audio oscillator frequency. Now vary the audio oscillator frequency so as to maintain the zero-beat condition, and follow the detected difference signal over its range. Note the audio oscillator frequencies at the two extremes of this range, and compute from them the mid-range frequency. This mid-range frequency should be adjusted, by means of trimmer capacitor C1, to 10,625 cps. An error of 59 cycles per second at the frequency of the detected signal arising from errors such as those incurred in audio oscillator calibration represents an error of one cycle per second at the color sampling frequency.

Part II

Companion Unit to Interlaced Sampling-Signal Generator

General Discussion

The horizontal synchronizing signal utilized for experimental transmissions of the National Television System Committee color-television system includes, in addition to the horizontal blanking pulse and horizontal sync pulse, a burst of the color-sampling frequency riding on a burst pedestal. The timing and duration of the components of this signal are usually given in decimal parts of H, the line repetition period. Adjustment of the waveform to the required values is facilitated by a source of marker pulses which repeat at a known decimal part of H.

One section of the Companion Unit to the Interlaced Sampling-Signal Generator provides such a source of marker pulses, adjustable in phase, occurring at a repetition period of 0.01 H.

The other section of the Companion Unit consists of three distribution amplifiers for the color sampling signal, providing three independent outputs. Independence of outputs is particularly advantageous for experimental work.

Description of Circuits

The marker-pulse section of the Companion Unit, the schematic of which is shown in Fig. 6, is composed of four stages: a multiplier stage, a limiter stage, an amplifier-rectifier stage, and an output stage.

The multiplier stage utilizes one section of a 6J6, V201A. It is driven from the 31.5-kc signal originating at the plate of the 31.5-kc output stage, V106B, of the Interlaced Sampling-Signal Generator. This signal is available at J12 in that unit. J12 should be connected to J15 of the Companion Unit; J15 is connected to the variable phase-shift network, which is in turn connected to the multiplier grid. The phase-shift is controlled by the *Marker-Pulse Position* potentiometer, P2.

The output of the multiplier, at 787.5 kc (25 x 31.5 kc), is amplified and limited by V201B, the second section of the 6J6. The signal at the grid of the limiter is shown in Fig. 7a.

The limiter drives the amplifier, V202A, one section of a 12AU7. The limiter output, measured at the grid of V202A, is shown in Fig. 7b. The double-ended plate load is shunt-fed; the balanced signal is full-wave rectified by two 1N34 crystal diodes. The repetition frequency of this signal is thus 2 x 787.5 kc, or 1575 kc which is 100 times the 15,750 cps horizontal sync frequency.

The full-wave rectified signal drives the cathode-follower output stage, V202B. The cathode load is the *Marker-Pulse Amplitude* potentiometer, P3. The *Marker-Pulse Output* is made available at the coax-receptacle, J16, and at the pin-jack, J17. The output signal consists of positive pulses of 0-8 volts amplitude, adjustable, occurring at a repetition period of 0.01 H. The marker-pulse output is shown in Fig. 7c. The pulse-position is adjustable over the full range of the repetition period.

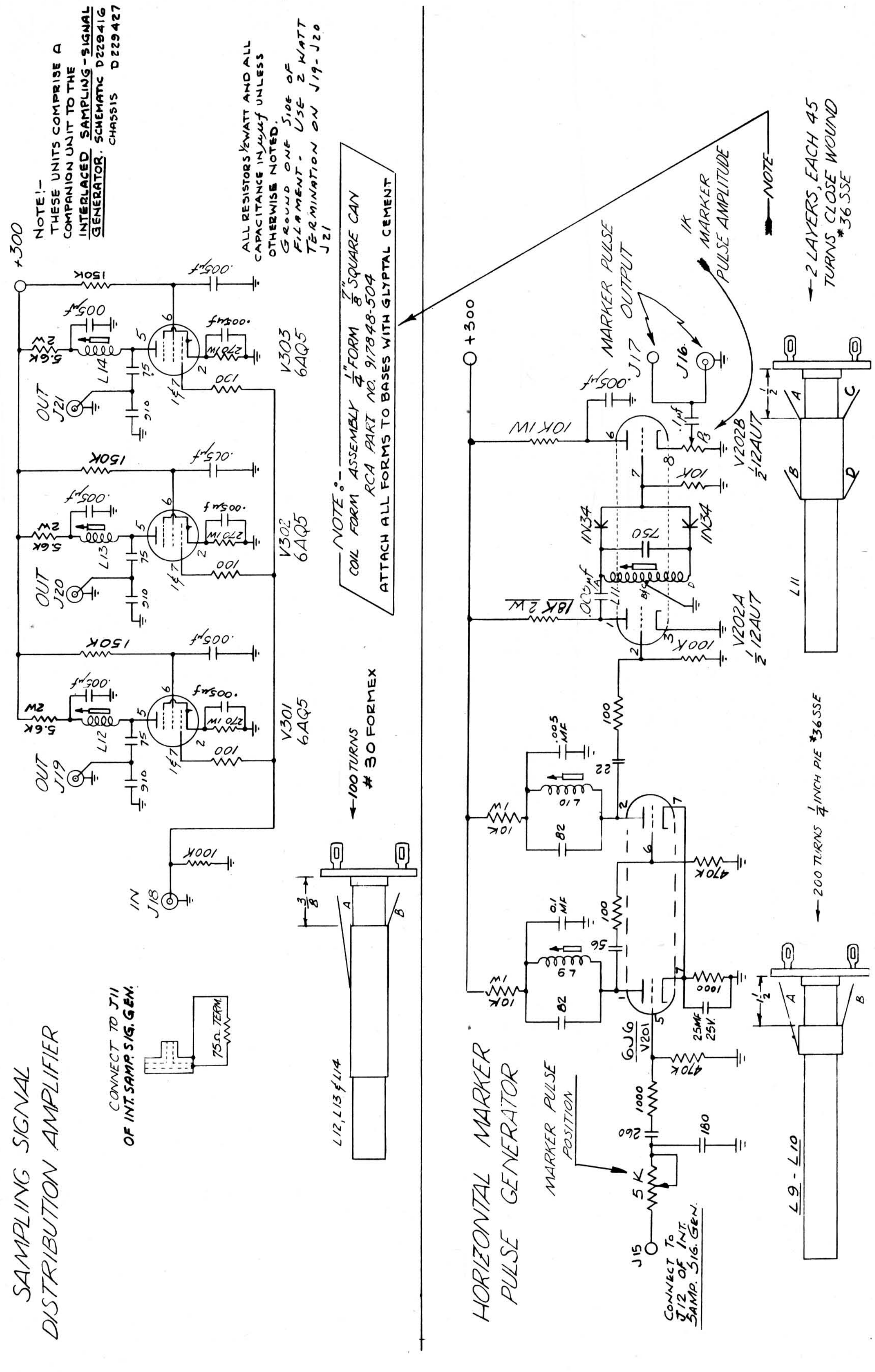
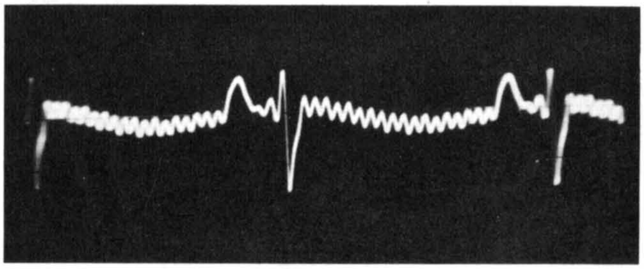
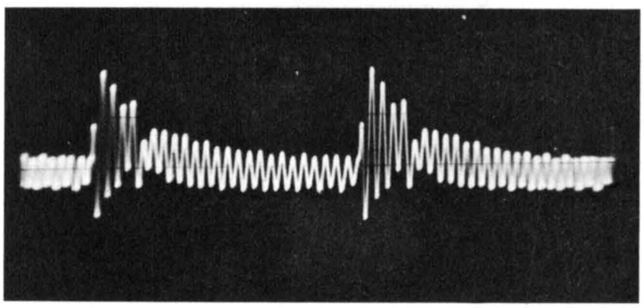


Fig. 6 - Schematic diagram of Companion Unit to Interlaced Sampling-Signal Generator.

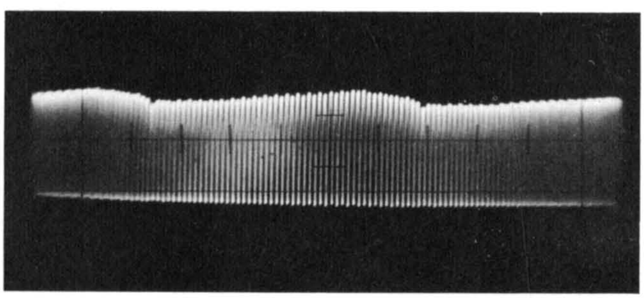
The distribution amplifier section of the Companion Unit is composed of three 6AQ5 amplifiers, V301, V302, and V303. The outputs are available at the coaxial receptacles, J19, J20, and J21. The amplifiers are designed to be driven from the *Color-Frequency Output*, terminated, of the Interlaced Sampling-Signal Generator. This termination may be a terminated line, permitting further utilization of the *Color-Frequency Output*.



(a) Waveform at grid of limiter, V201B; 8v p-p.



(b) Signal at grid of V202A; 8v p-p.



(c) Output of marker-pulse generator; 8v p-p.

Fig. 7 - Waveforms of marker pulse generator.

Both sections are mounted on a standard 3½-inch dishpan chassis. Power requirements are 150 ma at 300 volts and 2 amps at 6.3 volts. Front and rear views are shown in Figs. 8 and 9.

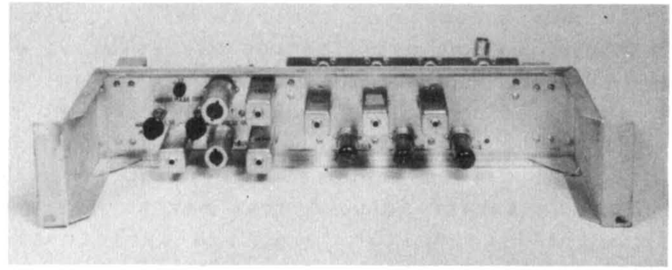


Fig. 8 - Front view of Companion Unit.

Adjustment

The Companion Unit should be mounted either immediately above or below the Interlaced Sampling-Signal Generator. A short wire, terminated in pin-plugs is used to connect J12 of the latter unit to J15 of the former.

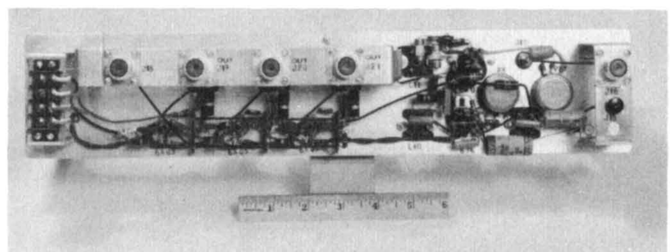


Fig. 9 - Rear view of Companion Unit.

The plate loads of V201A, V201B, and V202A in the Companion Unit must now be tuned to 787.5 kc. This is most readily accomplished by observation of the *Marker-Pulse Output* on an oscilloscope, the sweep of which is synchronized by horizontal drive, or the 31.5-kc output available at J9. The waveform observed will consist of a full-wave rectified sinusoid of high frequency, with irregularities in amplitude which repeat symmetrically at 31.5-kc repetition rate. L9, L10, and L11 should be tuned to maximize this signal; this will greatly reduce the irregularities in amplitude. For proper tuning, there are 50 pulses in a repetition interval. The pulses in a repetition interval should be counted and the coils should be tuned to achieve the proper number of pulses. Tuning L9, in the multiplier plate load, is most effective.

The marker pulse section of the Companion Unit has now been adjusted. The *Marker-Pulse*

Output may be employed conventionally to blank the trace of the oscilloscope presentation of any waveform whose repetition rate is controlled by the Interlaced Sampling-Signal Generator. It may also be convenient to add marker pulses to the signal to be observed. To accomplish this, the *Marker-Pulse Output* may be coupled by a small capacitor (e.g., 18 μμf) to the terminated line carrying the signal in question. The differentiated marker pulses thus added to the signal are approximately sawtooth in form: they effectively interrupt the signal at 0.01 H intervals. The combined signal may be adjusted to the desired appearance by the *Marker-Pulse Amplitude* control.

The color-frequency distribution amplifier section of the Companion Unit is driven from the Color-Frequency Output of the Interlaced Sampling-Signal Generator. A short length of cable should be connected from J11 of the latter unit to a coaxial Tee mounted on J18 of the Companion Unit. The free arm of the Tee should be terminated. The outputs at J19, J20, and J21 may be adjusted by tuning L12, L13, and L14, respectively; 30 volts p-p into 75 ohms is available at these outputs, and 2-watt terminations should be used.

T. O. Stanley

N. D. Larky

D. D. Holmes